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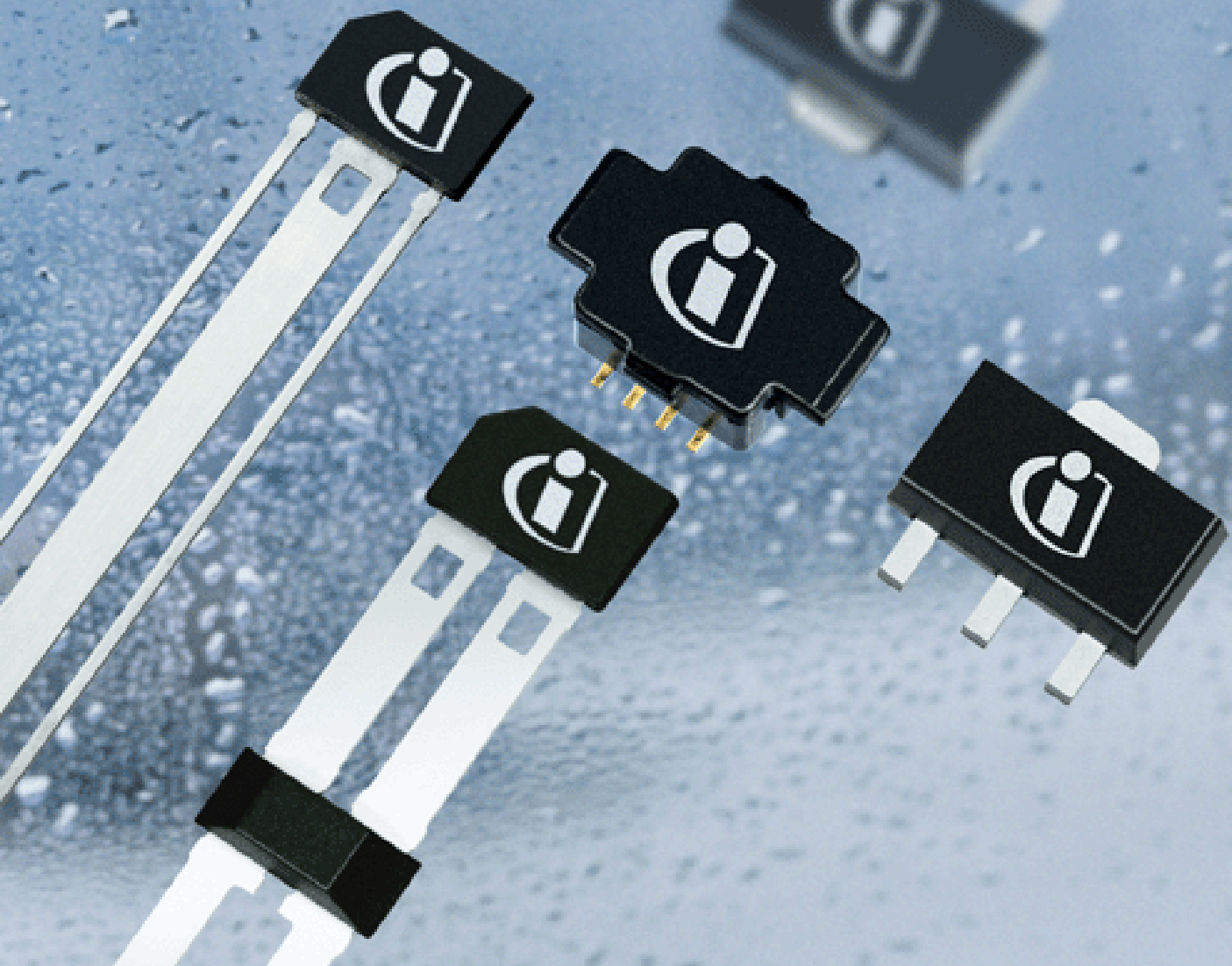
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TLE4923

Dynamic Differential Hall Effect Sensor IC



Sensors



Never stop thinking.

Edition 2005-04

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V 1.0

Previous Version: none

| Page | Subjects (major changes since last revision) |
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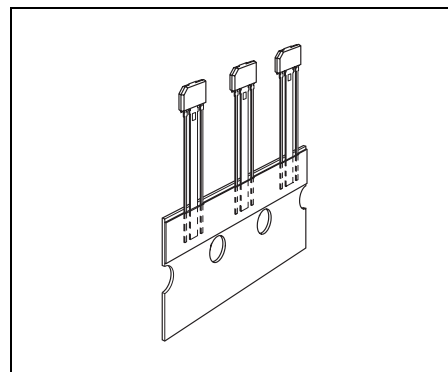


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1 Overview

1.1 Features

- Advanced performance
- Higher sensitivity
- Symmetrical thresholds
- High piezo resistivity
- Reduced power consumption
- South and north pole pre-induction possible
- AC coupled
- Digital output signal
- Two-wire interface
- Large temperature range
- Large airgap
- Low cut-off frequency
- Protection against reversed polarity



The differential Hall effect sensor TLE4923 is compatible to the TLE4921-3U, except for having a 2-wire interface. The TLE4923 provides high sensitivity, a superior stability over temperature and symmetrical thresholds in order to achieve a stable duty cycle. TLE4923 is particularly suitable for rotational speed detection and timing applications of ferromagnetic toothed wheels such as in anti-lock braking systems, transmissions, crankshafts, etc. The integrated circuit (based on Hall effect) provides a digital signal output with frequency proportional to the speed of rotation. Unlike other rotational sensors differential Hall ICs are not influenced by radial vibration within the effective airgap of the sensor and require no external signal processing.

| Type | Marking | Ordering Code | Package |
|---------|---------|---------------|------------|
| TLE4923 | 4923 B | Q62705-K408 | PG-SSO-3-6 |

1.2 Pin Configuration (top view)

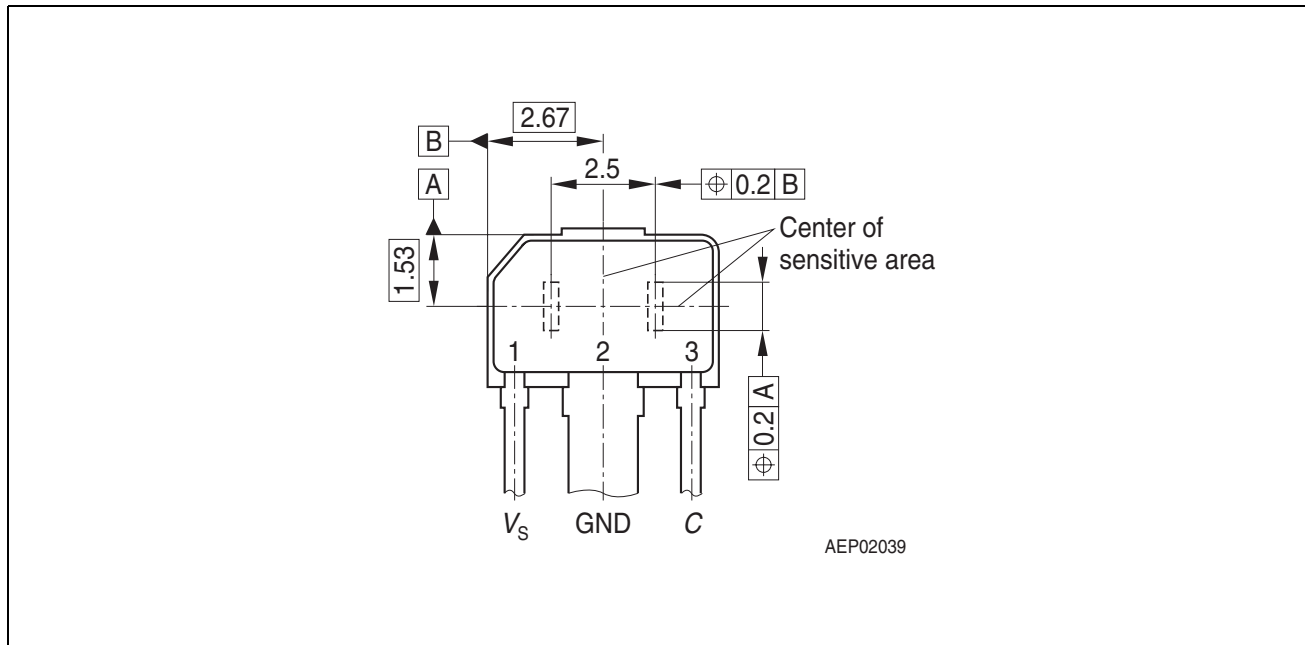


Figure 1

Table 1 Pin Definitions and Functions

| Pin No. | Symbol | Function |
|---------|--------|----------------|
| 1 | V_S | Supply voltage |
| 2 | GND | Ground |
| 3 | C | Capacitor |

2 General

2.1 Block Diagram

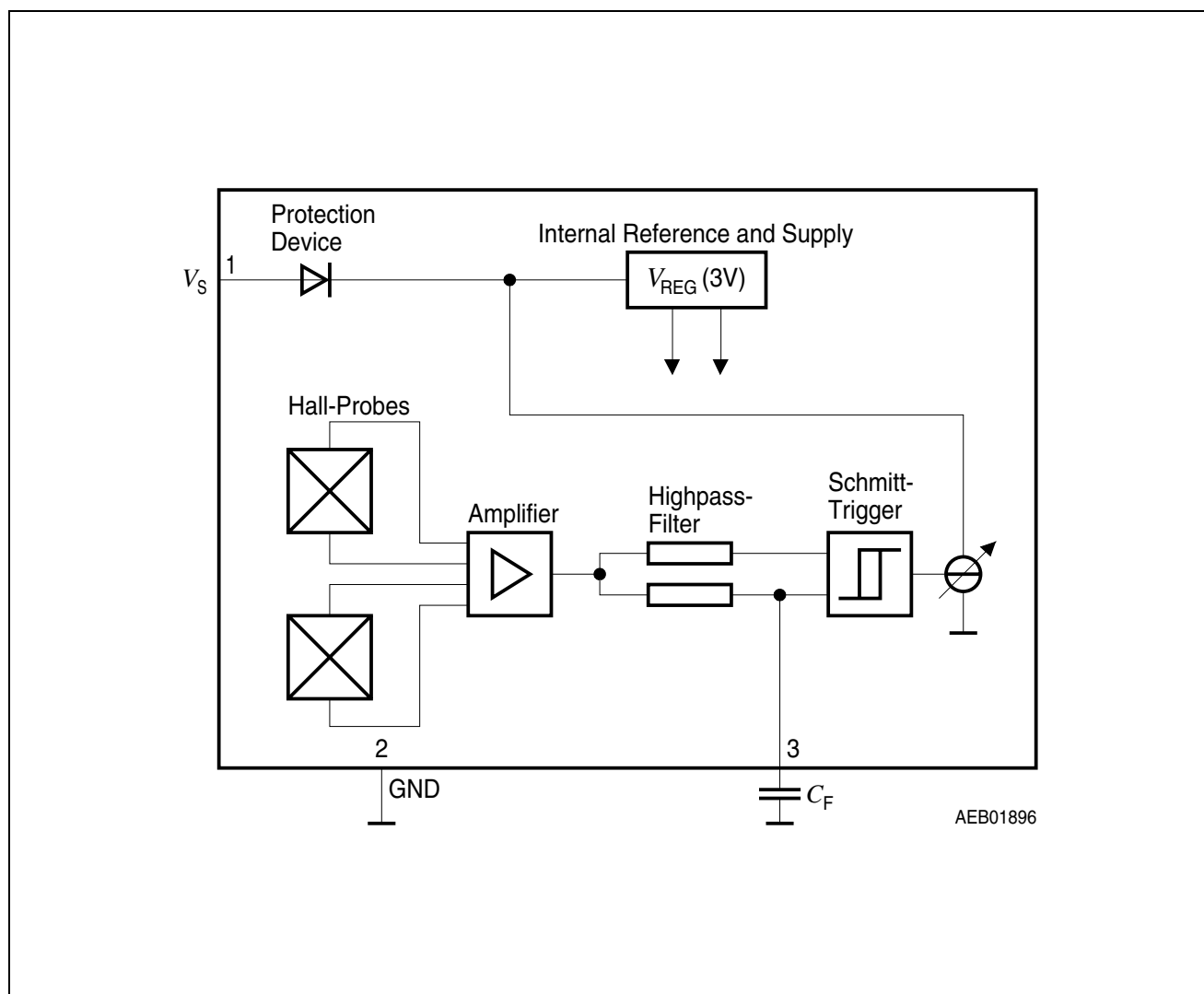


Figure 2 Block Diagram

2.2 Functional Description

The Differential Hall sensor IC detects the motion and position of ferromagnetic and permanent magnet structures by measuring the differential flux density of the magnetic field. To detect ferromagnetic objects the magnetic field must be provided by a back biasing permanent magnet (**south or north** pole of the magnet attached to the rear unmarked side of the IC package).

Using an external capacitor the generated Hall voltage signal is slowly adjusted via an active high pass filter with low frequency cut-off. This causes the output to switch into a biased mode after a time constant is elapsed. The time constant is determined by the external capacitor. Filtering avoids aging and temperature influence from Schmitt-trigger input and eliminates device and magnetic offset.

The TLE4923 can be exploited to detect toothed wheel rotation in a rough environment. Jolts against the toothed wheel and ripple have no influence on the output signal.

The on and off state of the IC are indicated by high and low current consumption.

2.3 Circuit Description (see [Figure 2](#))

The TLE4923 is comprised of a supply voltage reference, a pair of Hall probes spaced at 2.5 mm, differential amplifier, filter for offset compensation, Schmitt-trigger, and a switched current source.

The TLE4923 was designed to have a wide range of application parameter variations. Differential fields up to ± 40 mT can be detected without influence to the switching performance. The pre-induction field can either come from a magnetic south or north pole, whereby the field strength up to 500 mT or more will not influence the switching points¹⁾. The improved temperature compensation enables a superior sensitivity and accuracy over the temperature range. Finally, the optimized piezo compensation and the integrated dynamic offset compensation enable easy manufacturing and elimination of magnet offsets.

Protection is provided at the input/supply (pin 1) for reverse polarity.

1) Differential bias fields exceeding ± 20 mT, e. g. caused by a misaligned magnet, should be avoided.

Maximum Ratings

3 Maximum Ratings

Table 2 Absolute Maximum Ratings

| Parameter | Symbol | Limit Values | | Unit | Remarks |
|----------------------|------------|-------------------|--------------------------|------|----------------------------------|
| | | min. | max. | | |
| Supply voltage | V_S | -18 ¹⁾ | 24 | V | |
| Capacitor voltage | V_C | -0.3 | 3 | V | |
| Junction temperature | T_j | — — — — | 150 160 170 190 | °C | 5000 h 2500 h 500 h 4 h |
| Storage temperature | T_S | -40 | 150 | °C | |
| Thermal resistance | R_{thJA} | — | 190 | K/W | ²⁾ |

1) Reverse current drawn by the device < 10 mA

2) Can be reduced significantly by further packaging process, e. g. overmolding.
The device is ESD protected up to 2 kV (HL test procedure)

*Note: Stresses above those listed here may cause permanent damage to the device.
Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

4 Operating Range

Table 3 **Operating Range**

| Parameter | Symbol | Limit Values | | | Unit | Conditions |
|------------------------|------------|--------------|------|------|------|--|
| | | min. | typ. | max. | | |
| Supply voltage | V_S | 4.5 | – | 18 | V | |
| Junction temperature | T_j | -40 | – | 150 | °C | 5000 h |
| | | – | – | 160 | | 2500 h |
| | | – | – | 170 | | 500 h |
| | | – | – | 190 | | 4 h |
| Pre-induction | B_0 | -500 | – | 500 | mT | At Hall probe; independent of magnet orientation |
| Differential induction | ΔB | -40 | – | 40 | mT | |

Note: Unless otherwise noted, all temperatures refer to junction temperature.

In the operating range the functions given in the circuit description are fulfilled.

Electrical Parameters

5 Electrical Parameters

Table 4 Electrical Characteristics

The device characteristics listed below are guaranteed in the full operating range.

| Parameter | Symbol | Limit Values | | | Unit | Test Condition | Test Circuit |
|--|---|---------------|-------------|----------------|----------------|--|--------------|
| | | min. | typ. | max. | | | |
| Supply current | I_S | 3.1 8.1 | 4.1 10.5 | 5.3 13.6 | mA mA | | 1 1 |
| Supply current difference | $I_{SON} - I_{SOFF}$ | 5.0 | 6.4 | 8.3 | mA | | 1 |
| Supply current ratio | I_{SON} / I_{SOFF} | 2 | 2.4 | 3 | | | 1 |
| Center of switching points: $(\Delta B_{OP} + \Delta B_{RP}) / 2$ | ΔB_m | -0.5 | 0 | 0.5 | mT | $\Delta B = 2.0 \text{ mT}$, $f = 200 \text{ Hz}$, $-40^\circ\text{C} < T_j \leq 150^\circ\text{C}$ ^{1) 2)} | 2 |
| Center of switching points: $(\Delta B_{OP} + \Delta B_{RP}) / 2$ | ΔB_m | -0.7 | 0 | 0.7 | mT | $\Delta B = 2.0 \text{ mT}$, $f = 200 \text{ Hz}$, $150^\circ\text{C} < T_j < 190^\circ\text{C}$ ^{1) 2)} | 2 |
| Hysteresis | ΔB_H | 1 | 1.5 | 2.2 | mT | $\Delta B = 2.0 \text{ mT}$, $f = 200 \text{ Hz}$ ³⁾ | 2 |
| Current rise time | t_r | — | — | 0.5 | μs | | 2 |
| Current fall time | t_f | — | — | 0.5 | μs | | 2 |
| Delay time ⁴⁾ | t_{dop} t_{drp} $t_{dop} - t_{drp}$ | | | 25 10 15 | μs μs μs | $f = 10 \text{ kHz}$, $\Delta B = 5 \text{ mT}$ | 2 |
| Filter input resistance | R_C | 35 | 43 | 52 | kΩ | $25^\circ\text{C} \pm 2^\circ\text{C}$ | 1 |
| Filter sensitivity to ΔB | S_C | | 8.5 | | mV/ mT | $25^\circ\text{C} \pm 2^\circ\text{C}$ | 1 |
| Filter bias voltage | V_C | 1.6 | 2.0 | 2.4 | V | $\Delta B = 0$ | 1 |
| Frequency | f | ⁵⁾ | | 10000 | Hz | $\Delta B = 5 \text{ mT}$ | 2 |

Electrical Parameters

Table 4 **Electrical Characteristics** (cont'd)

The device characteristics listed below are guaranteed in the full operating range.

| Parameter | Symbol | Limit Values | | | Unit | Test Condition | Test Circuit |
|---|--------------|--------------|------|------|------|---|-----------------|
| | | min. | typ. | max. | | | |
| Resistivity against mechanical stress (piezo) ⁶⁾ | ΔB_m | -0.1 | – | 0.1 | mT | F = 2 N | 2 |
| | ΔB_H | -0.1 | – | 0.1 | mT | | |
| Power supply rejection ratio (PSRR) | V_{PSRR} | 10 | – | – | V | V_S modulated with V_{PSRR} , $f_{PSRR} = 10$ kHz, $t_{r,fPSRR} = 1$ μ s, $\Delta B = 0$, only 1 transition may occur | 2 ⁷⁾ |

1) For ΔB values larger than ± 10 mT this value may exceed the limits as follows: $|\Delta B_m| < |0.05 \times \Delta B|$

2) Leakage currents at pin 3 should be avoided. The bias shift of B_m caused by a leakage current I_L can be

calculated by: $\Delta B_m = \frac{I_L \times R_C(T)}{S_C(T)}$. See also the typical curves on [Page 22](#).

3) Differential pre-induction (e.g. by magnetic misalignment) has to be smaller than 20 mT.

4) For definition see [Figure 6](#).

5) Depends on filter capacitor C_F . The cut-off frequency is given as $f = \frac{1}{2 \times \pi \times R_C \times C_F}$. The switching points are guaranteed over the whole frequency range, but amplitude modification and phase shift have to be taken into account due to the 1st order highpass filter.

6) For definition see [Figure 7](#).

7) For definition see [Figure 5](#).

Note: The listed characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not otherwise specified, typical characteristics apply at $T_j = 25^\circ\text{C}$ and the given supply voltage.

1) $R_C = \frac{\Delta V_C}{\Delta I_C}$

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Figure 3 Test Circuit 1

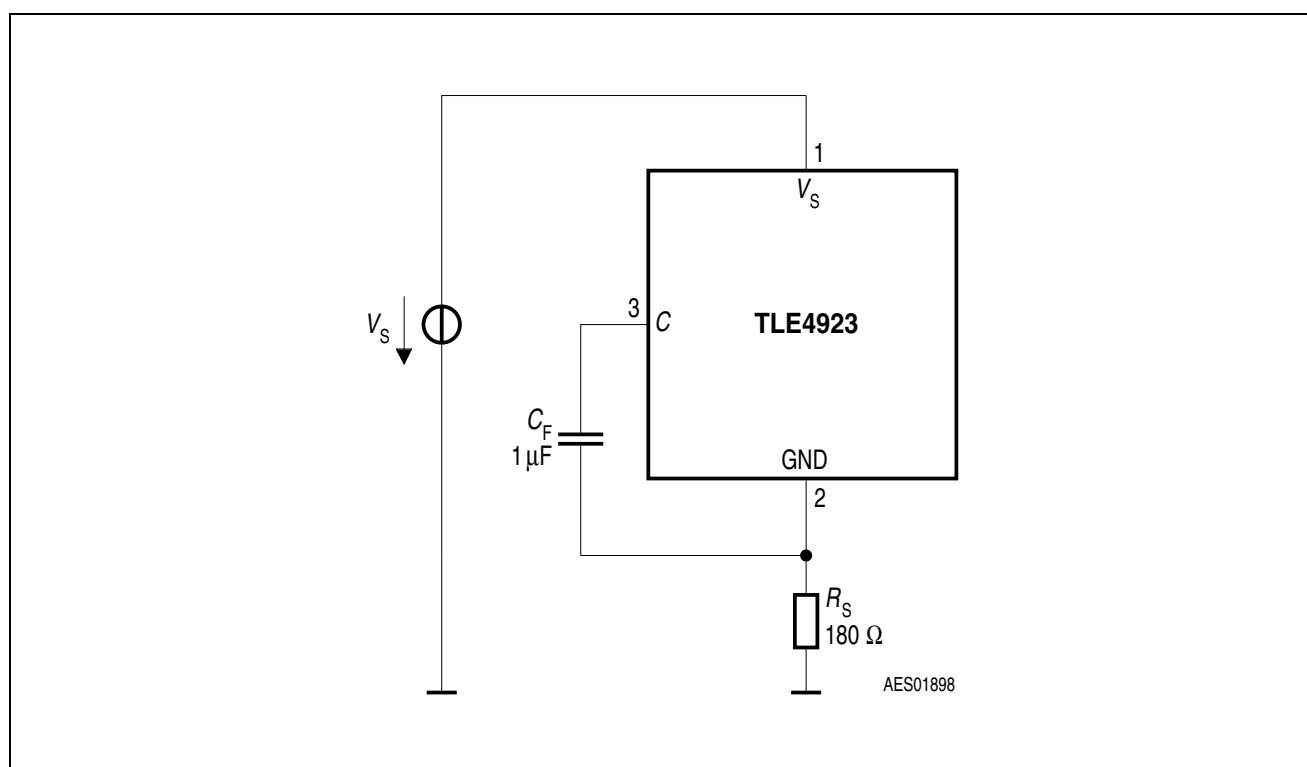


Figure 4 Test Circuit 2

Electrical Parameters

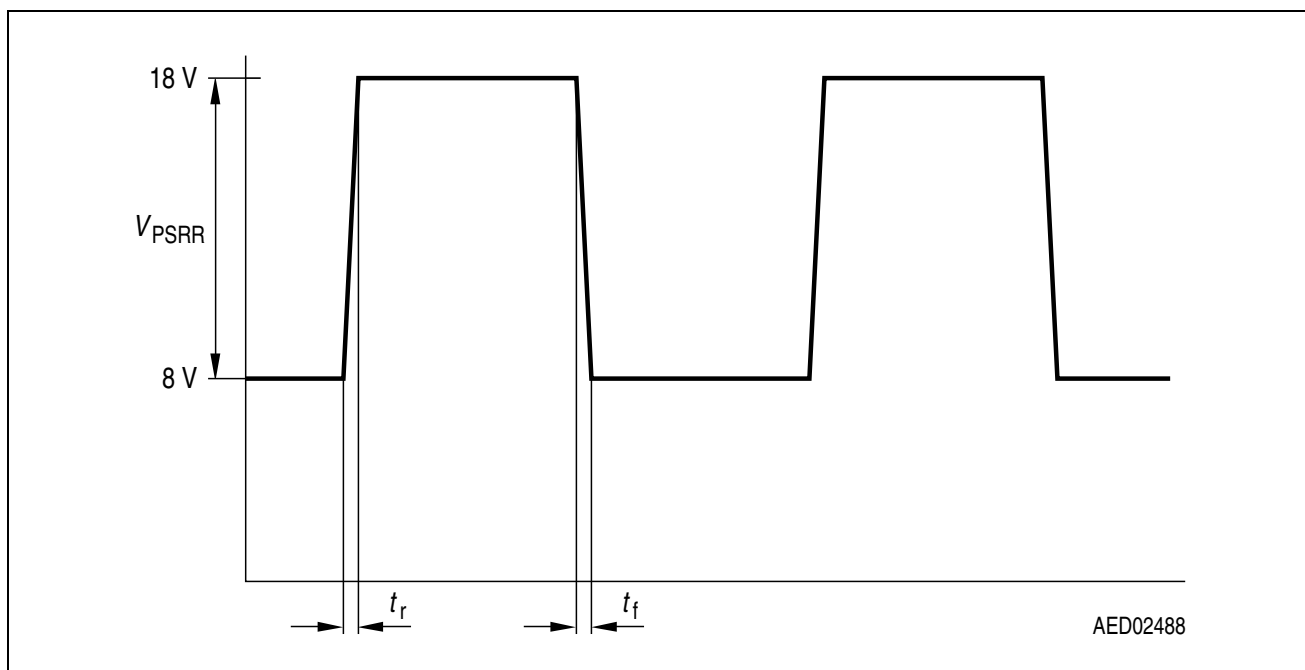


Figure 5

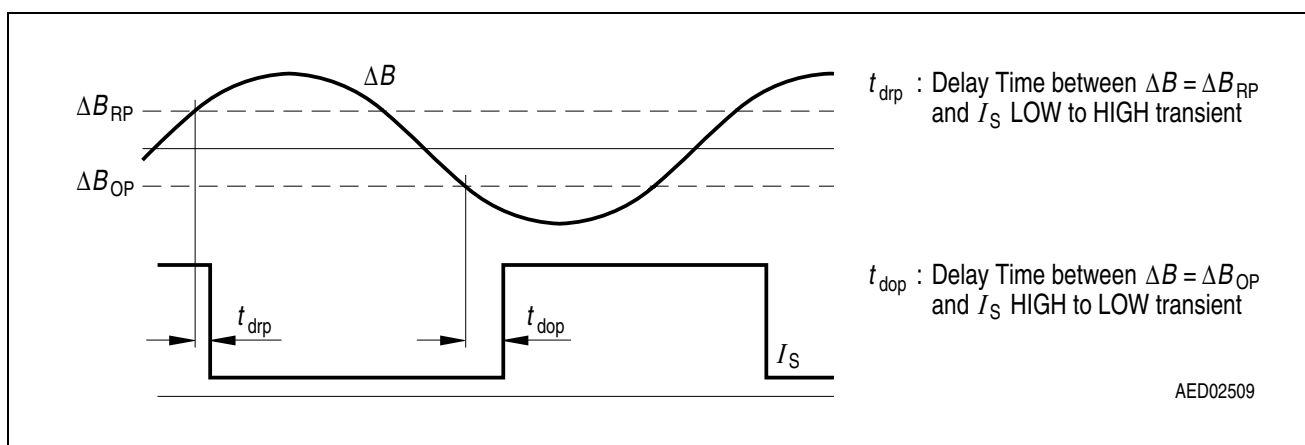


Figure 6 Definition of Delay Times (switching points related to initial measurement @ $\Delta B = 2 \text{ mT}$; $f = 200 \text{ Hz}$)

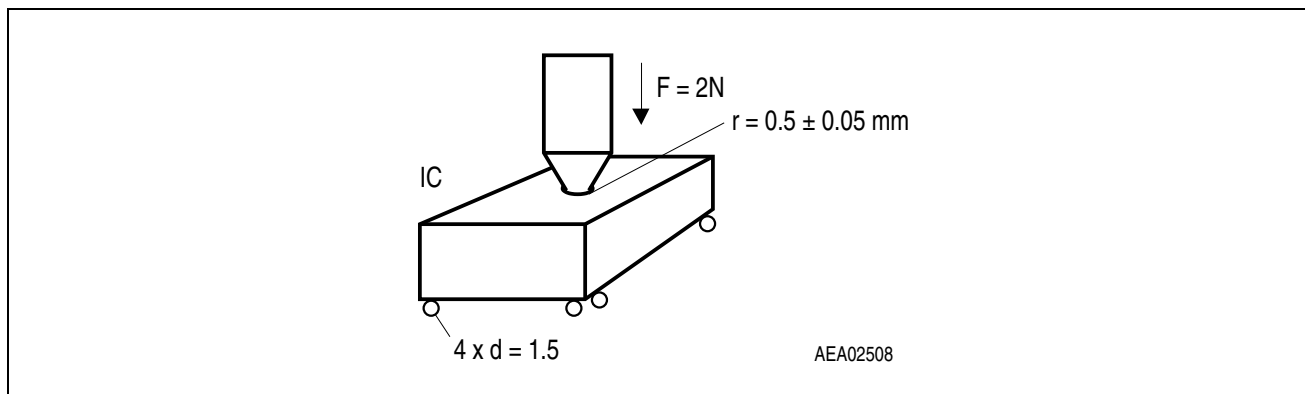


Figure 7 Setup for Piezo Measurements

6 Application Notes

Two possible applications are shown in [Figure 10](#) and [Figure 11](#) (Toothed and Magnet Wheel).

Two-wire application is shown in [Figure 12](#).

Gear Tooth Sensing

In the case of ferromagnetic toothed wheel applications the IC has to be biased by the south or north pole of a permanent magnet (e.g. SmCo₅ (Vacuumschmelze VX170) with the dimensions 8 mm × 5 mm × 3 mm) which should cover both Hall probes.

The maximum air gap depends on:

- the magnetic field strength (magnet used; pre-induction) and
- the tooth wheel that is used (dimensions, material, etc.; resulting differential field).

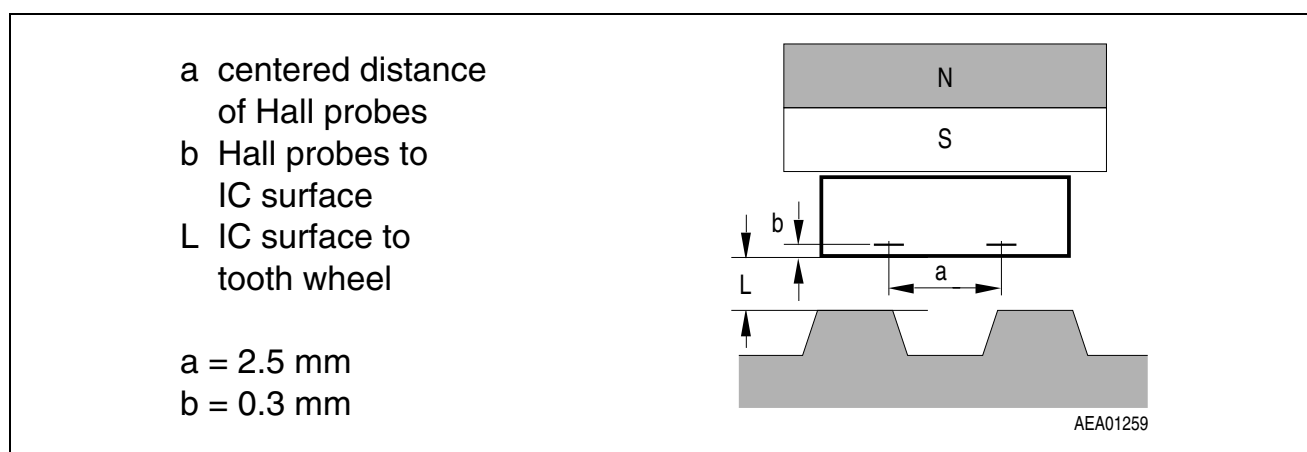


Figure 8 Sensor Spacing

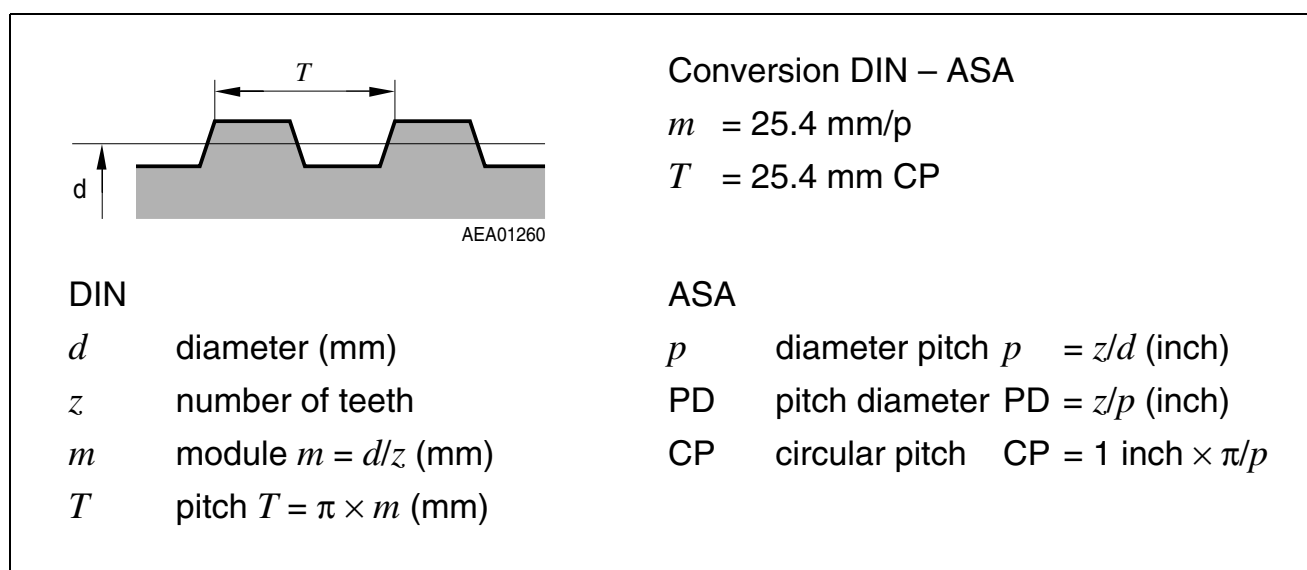


Figure 9 Tooth Wheel Dimensions

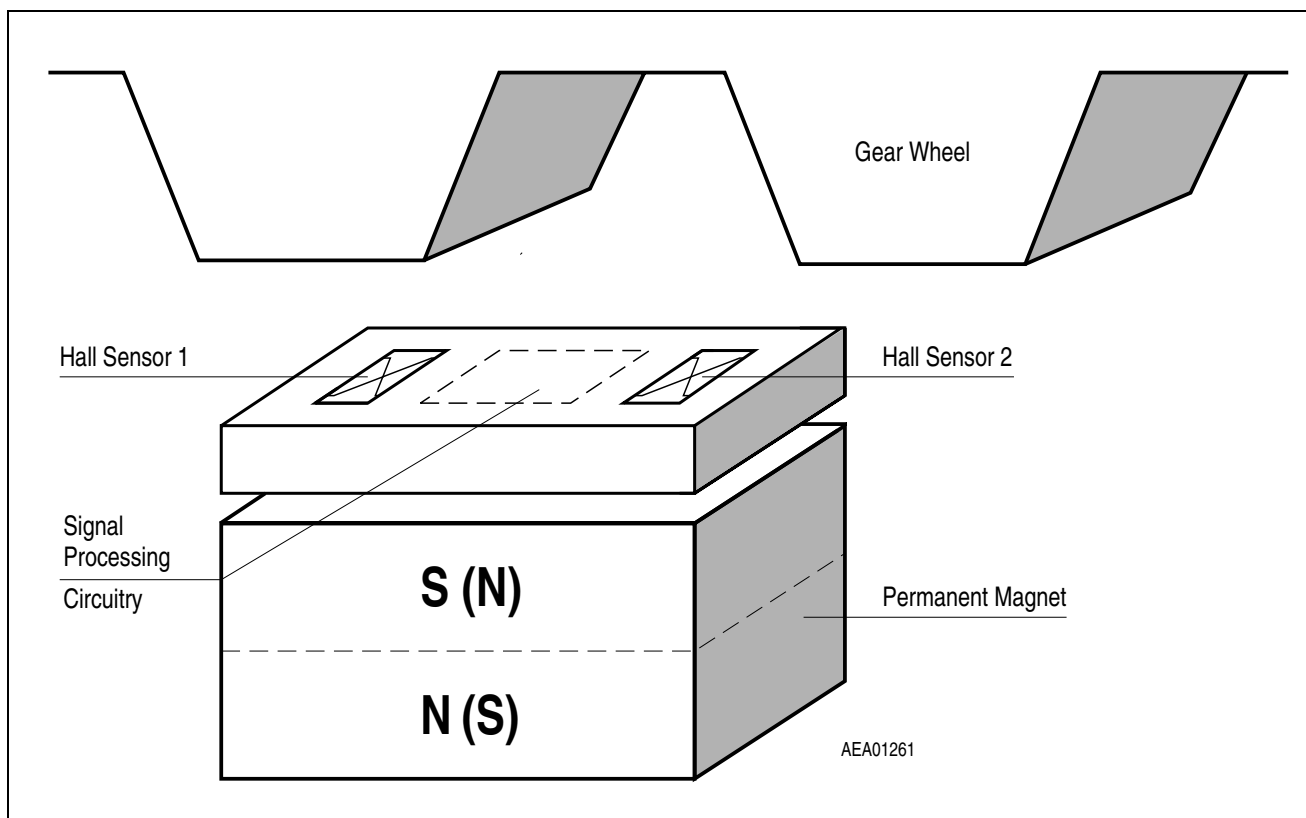


Figure 10 TLE4923, with Ferromagnetic Toothed Wheel

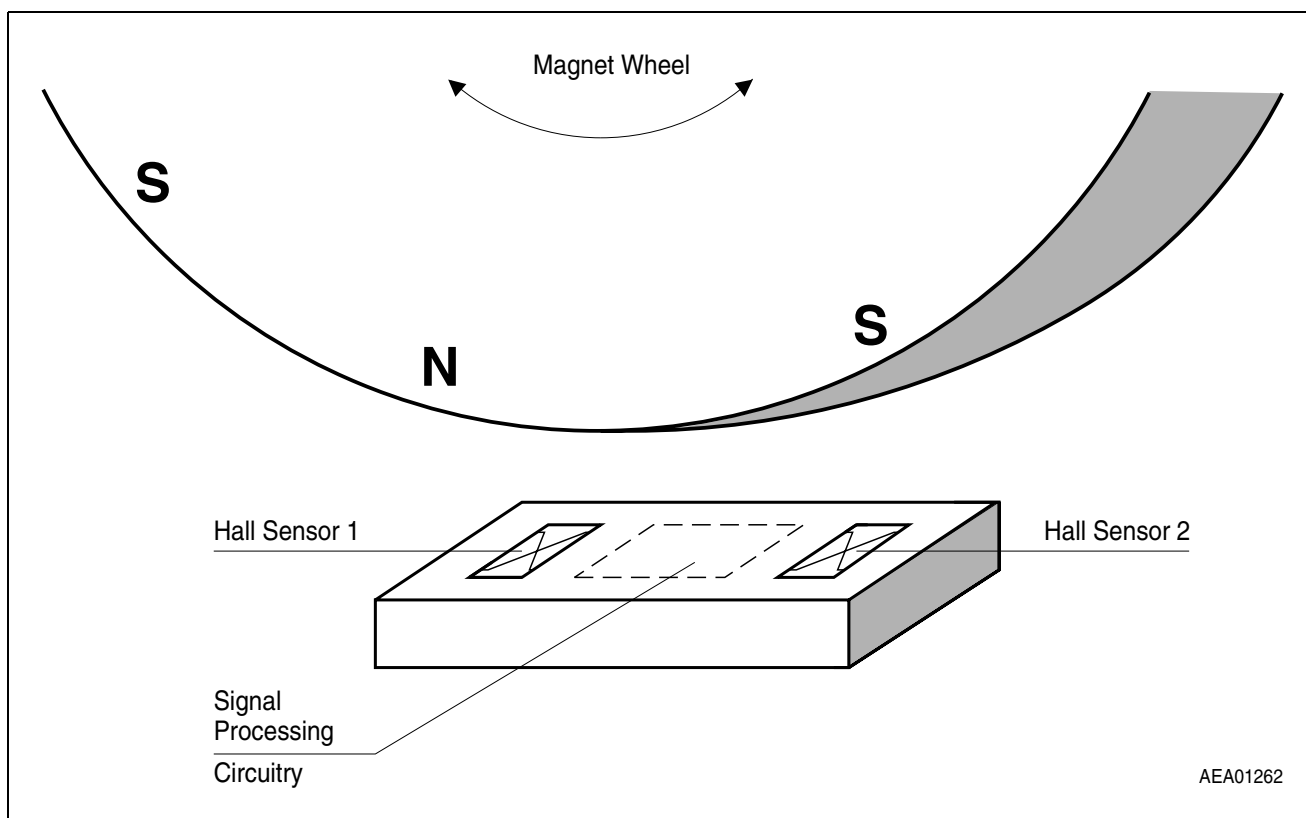


Figure 11 TLE4923, with Magnet Wheel

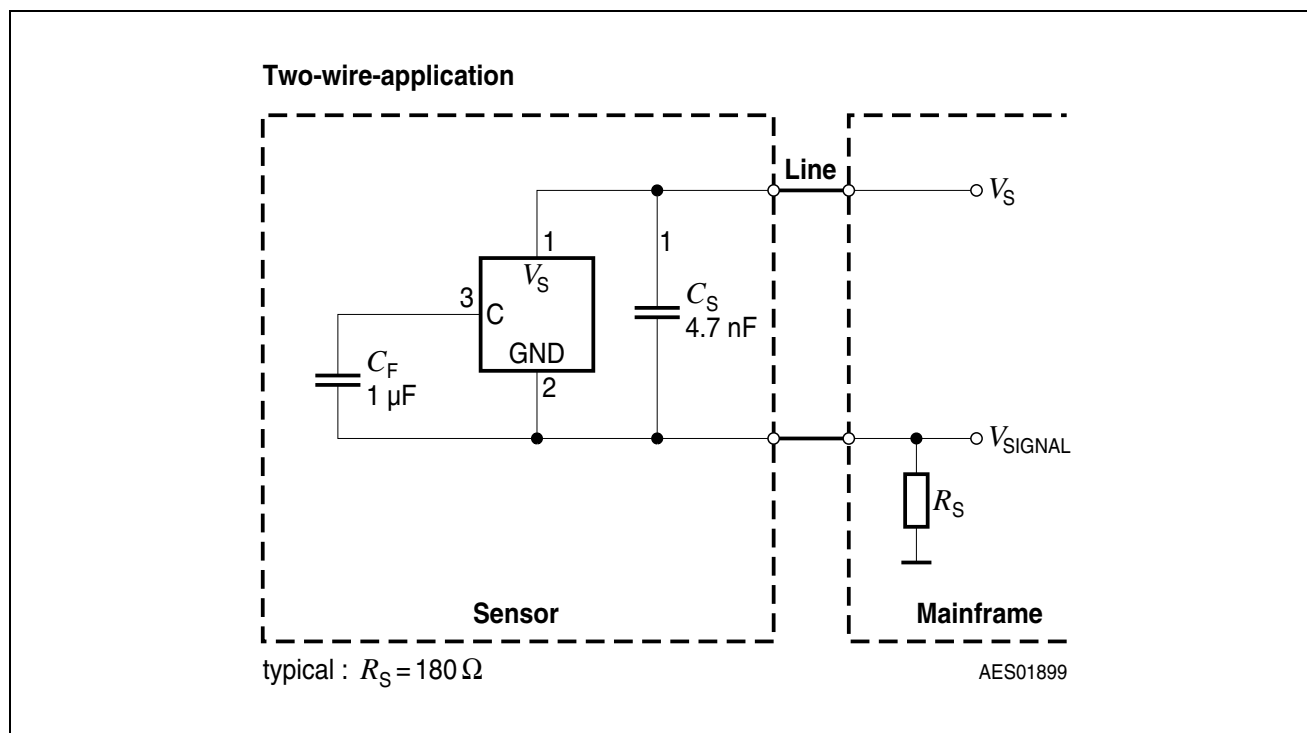


Figure 12 **Application Circuit**

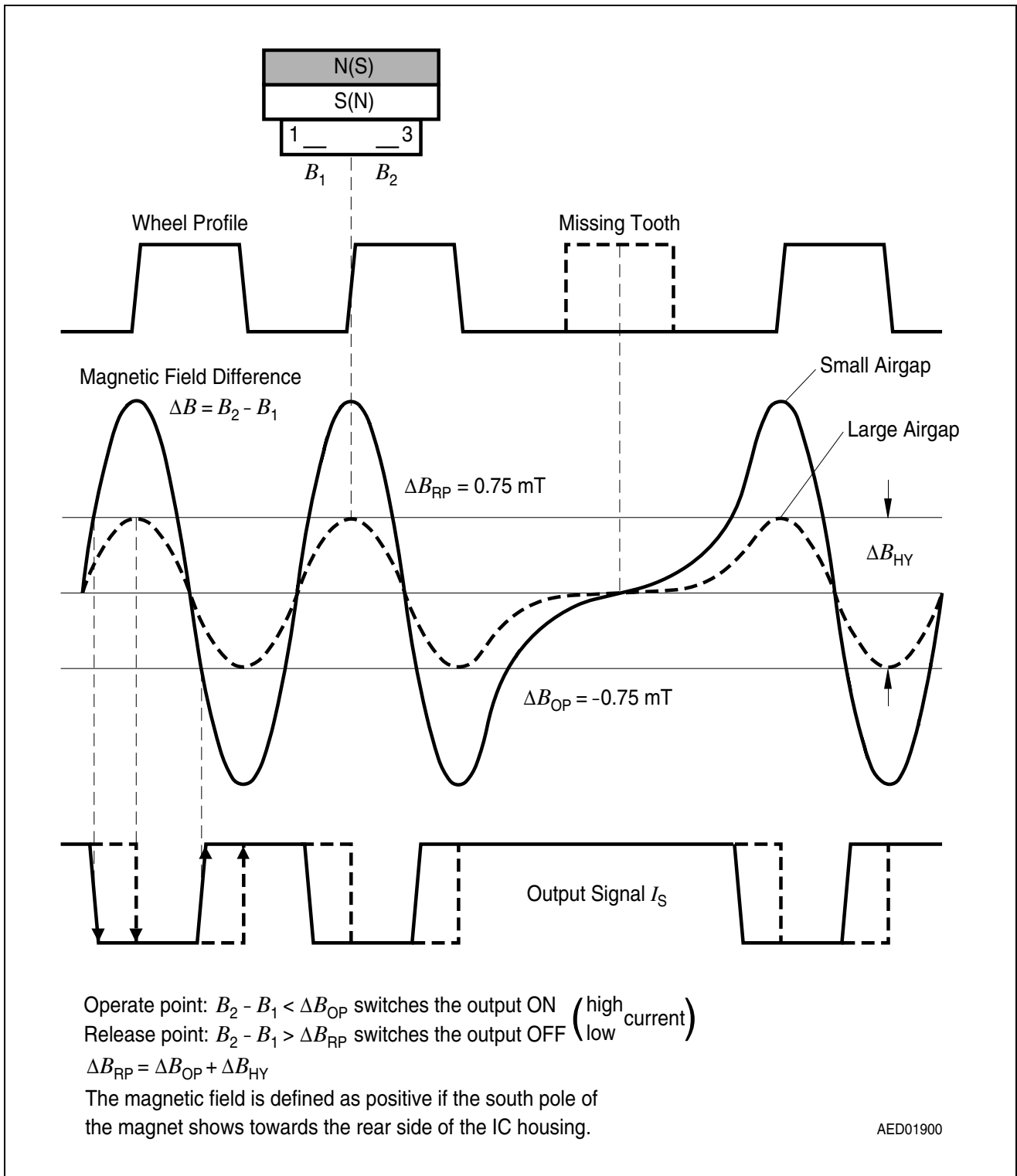


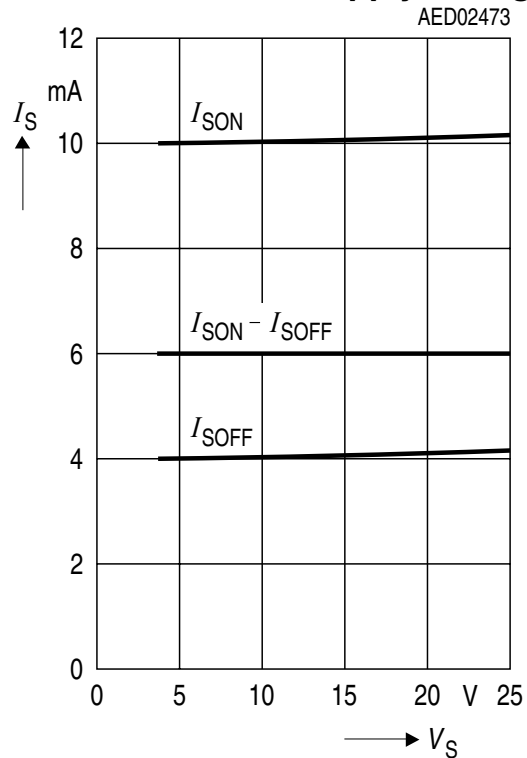
Figure 13 **System Operation**

Typical Performance Characteristics

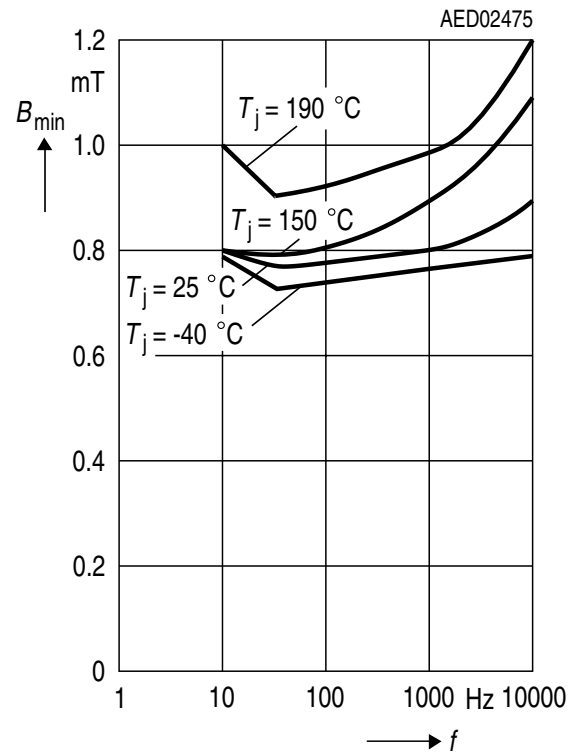
7 Typical Performance Characteristics

If not otherwise specified, all curves reflect typical values at $T_j = 25^\circ\text{C}$ and $V_S = 12\text{ V}$.

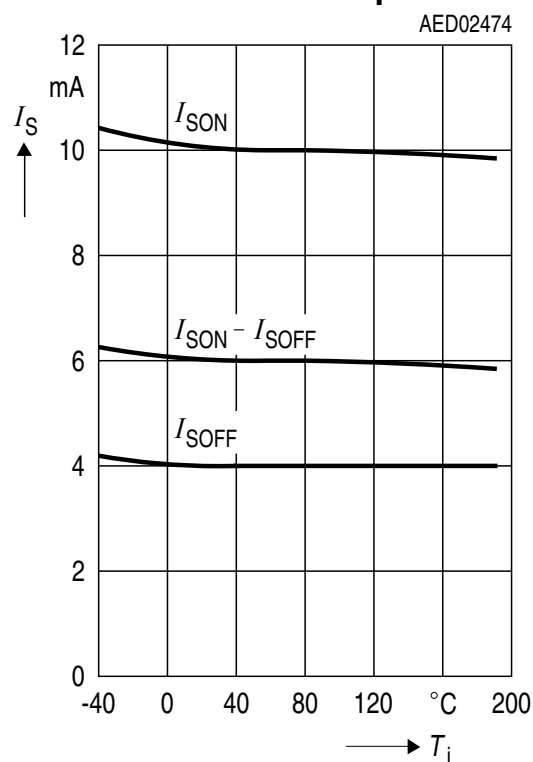
Supply Current and Supply Current Difference versus Supply Voltage



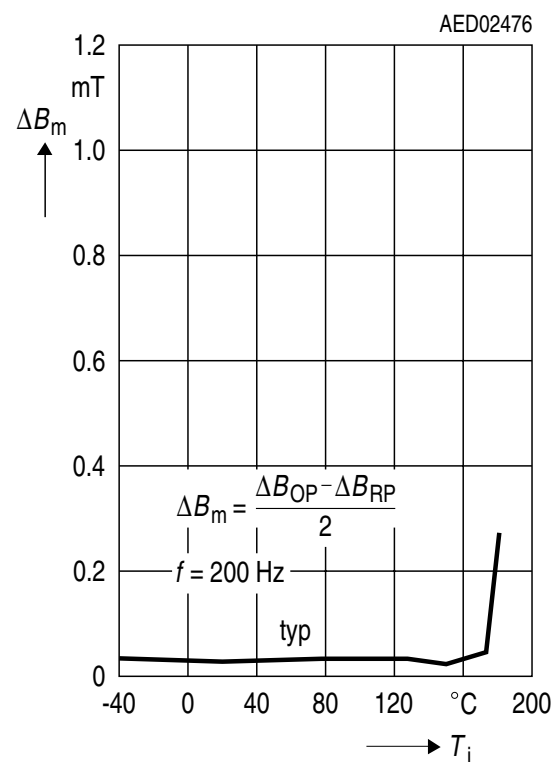
Minimum Switching Field versus Frequency



Supply Current and Supply Current Difference versus Temperature

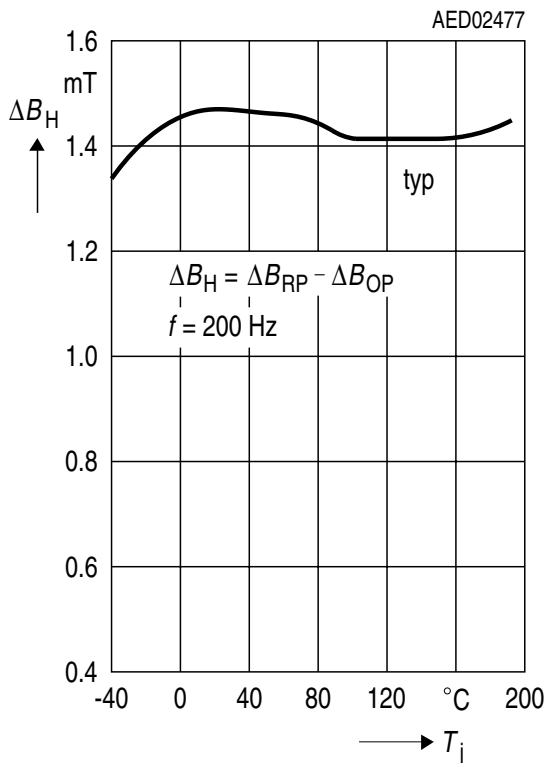


Mean Value of Switching Induction

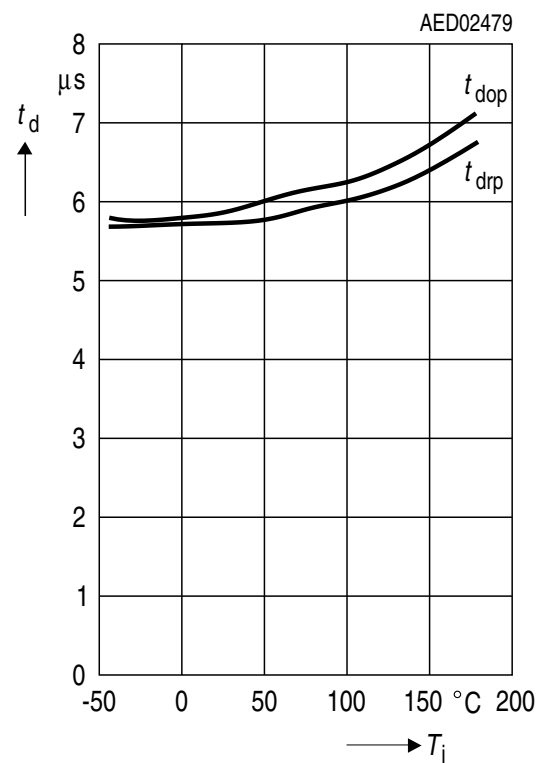


Typical Performance Characteristics

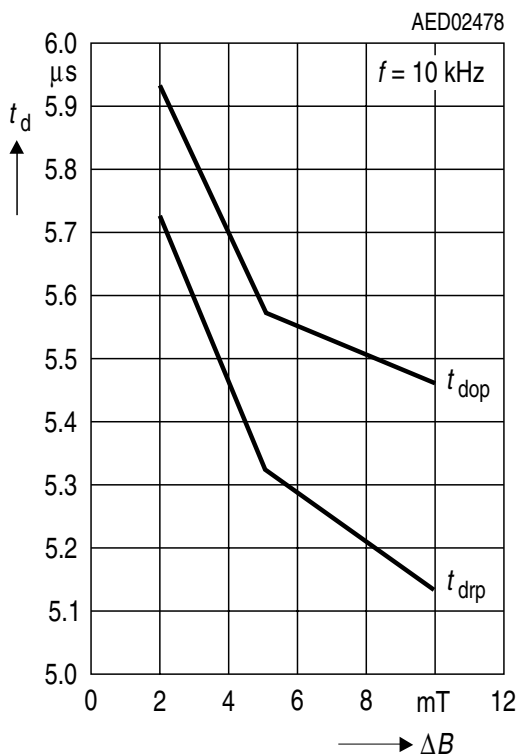
Hysteresis versus Temperature



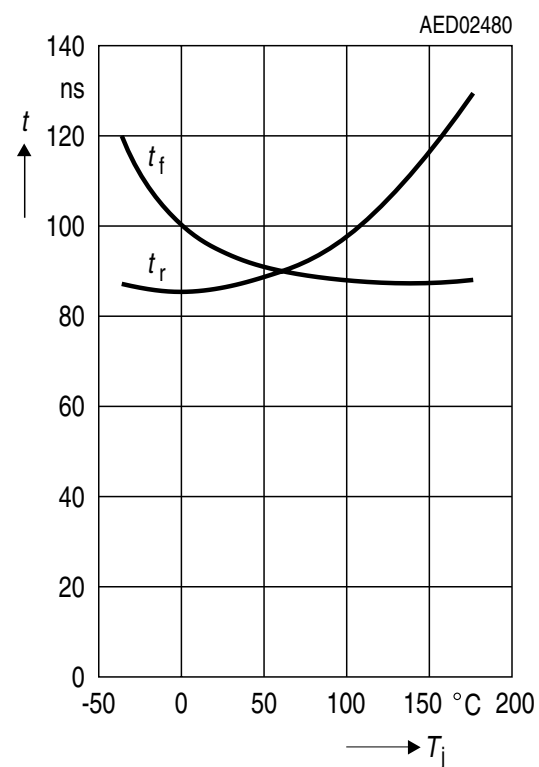
Delay Time ¹⁾ versus Temperature



Delay Time ¹⁾ versus Differential Field



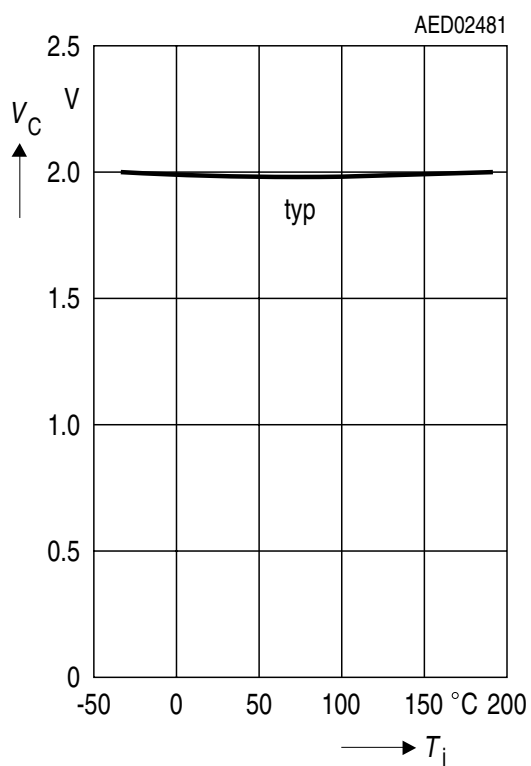
Rise and Fall Time versus Temperature



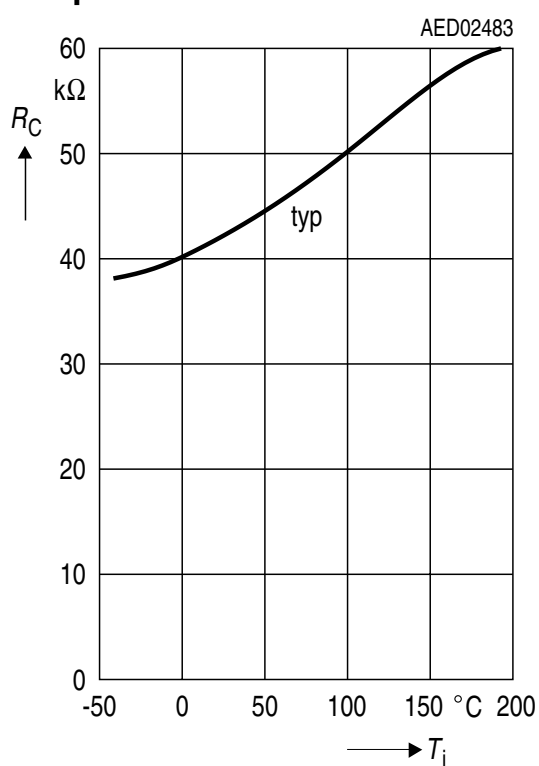
1) Switching points related to initial measurement @ $\Delta B = 2 \text{ mT}$, $f = 200 \text{ Hz}$

Typical Performance Characteristics

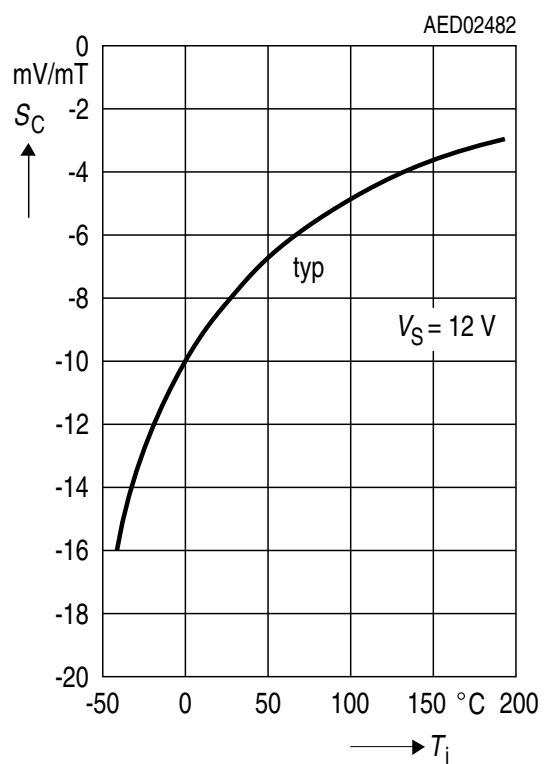
Capacitor Voltage versus Temperature



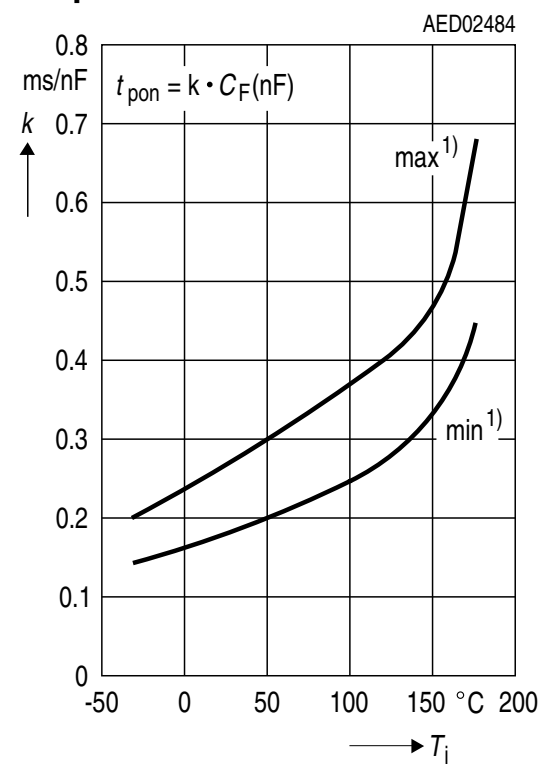
Filter Input Resistance versus Temperature



Filter Sensitivity versus Temperature



Delay Time t_{pon} for Power ON versus Temperature



1) Calculated values for minimum and maximum filter resistance, C_F at room temperature.

Typical Performance Characteristics

Threshold Shift versus Filter Leakage

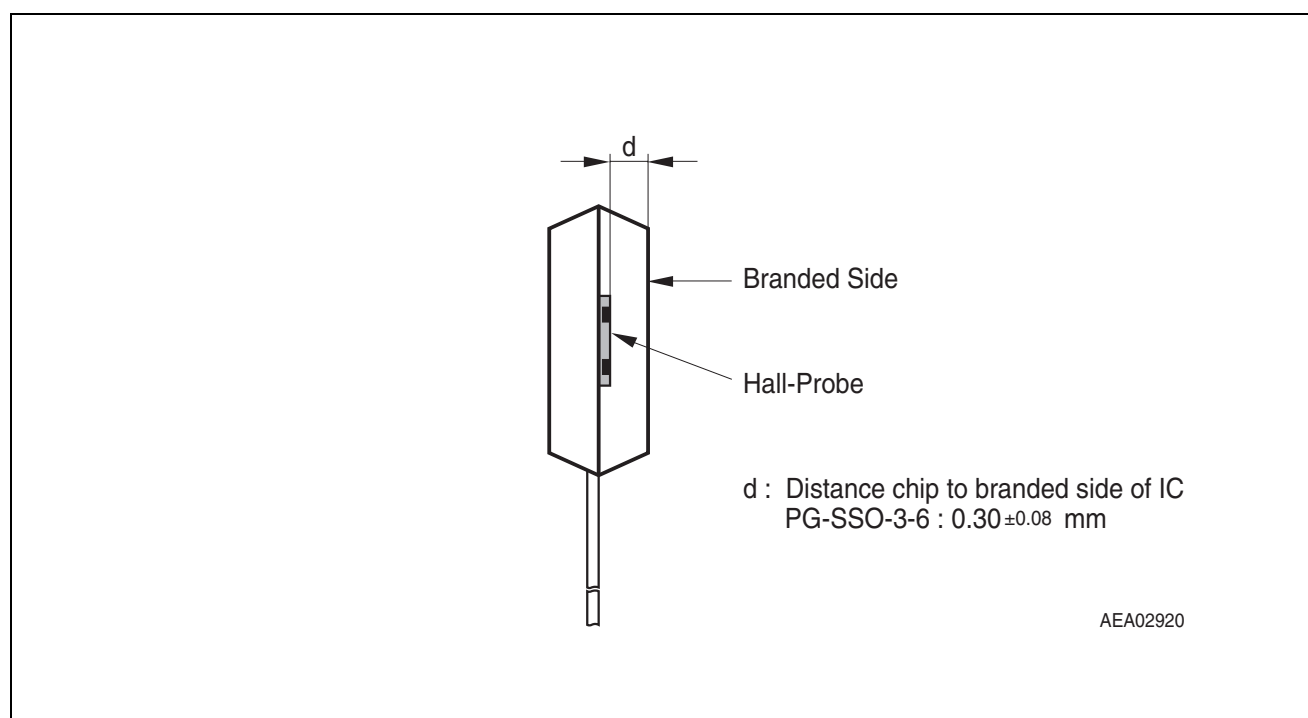
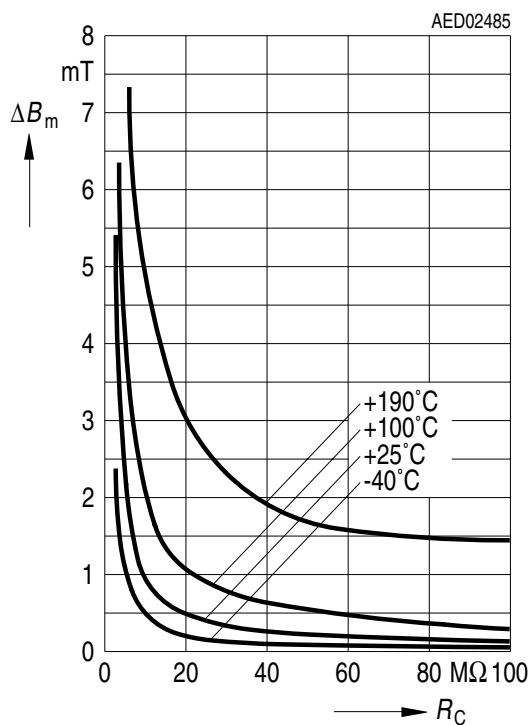


Figure 14 Distance Chip to Upper Side of IC

8 Package Outlines

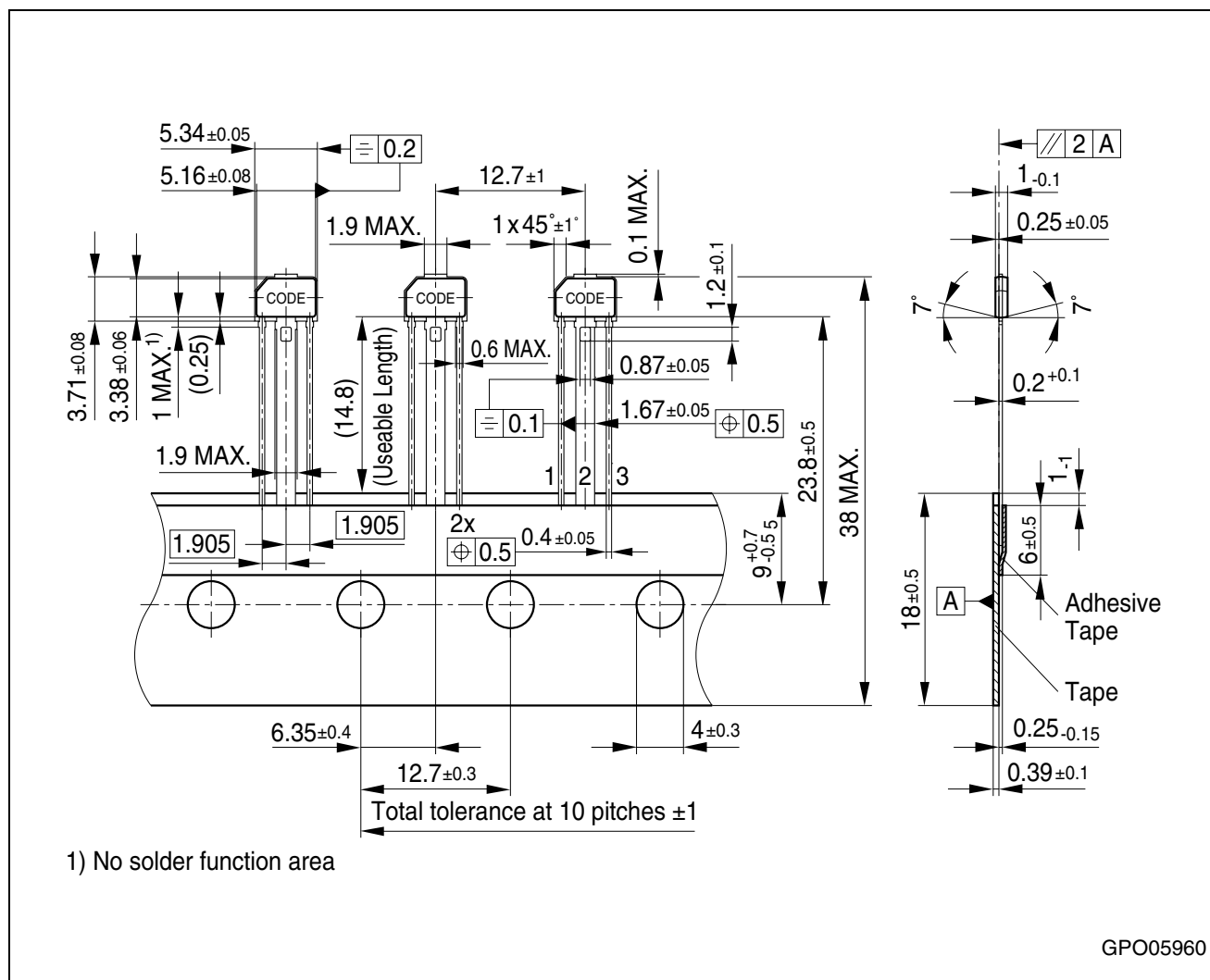


Figure 15 PG-SSO-3-6 (Plastic Single Small Outline Package)

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Dimensions in mm

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